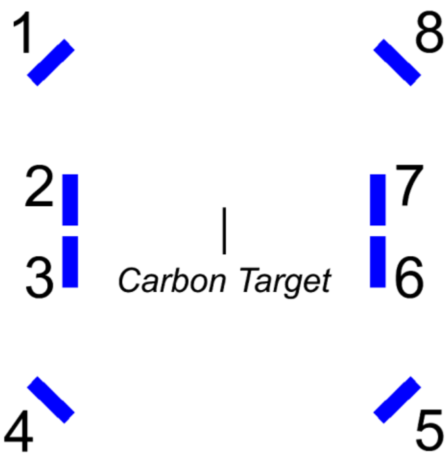
A. Poblaguev

Rate corrections in the AGS p-Carbon Polarimeter

- *Rate effect parameterization*
- *Experimental evaluation of the rate corrections*
- *Polarization measurements results after rate corrections.*

Reported at Spin Meeting 16 Nov 2011

AGS CNI Polarimeter 2011



3 different detector types:

1,8 - Hamamatsu, slow preamplifiers

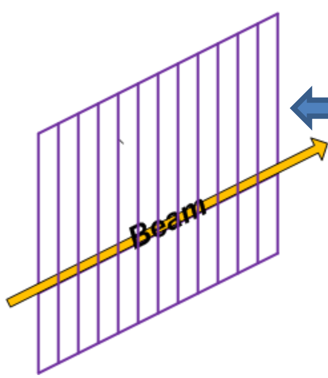
2,3,6,7 - BNL, fast preamplifiers

4,5 - Hamamatsu, fast preamplifiers

Larger length (50 cm)

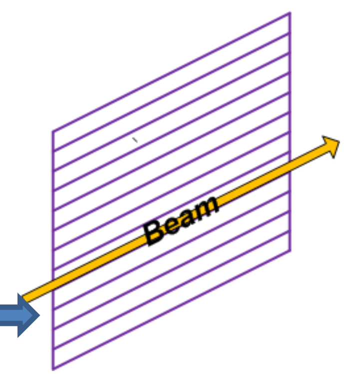
Regular length (30 cm)

Strip orientation



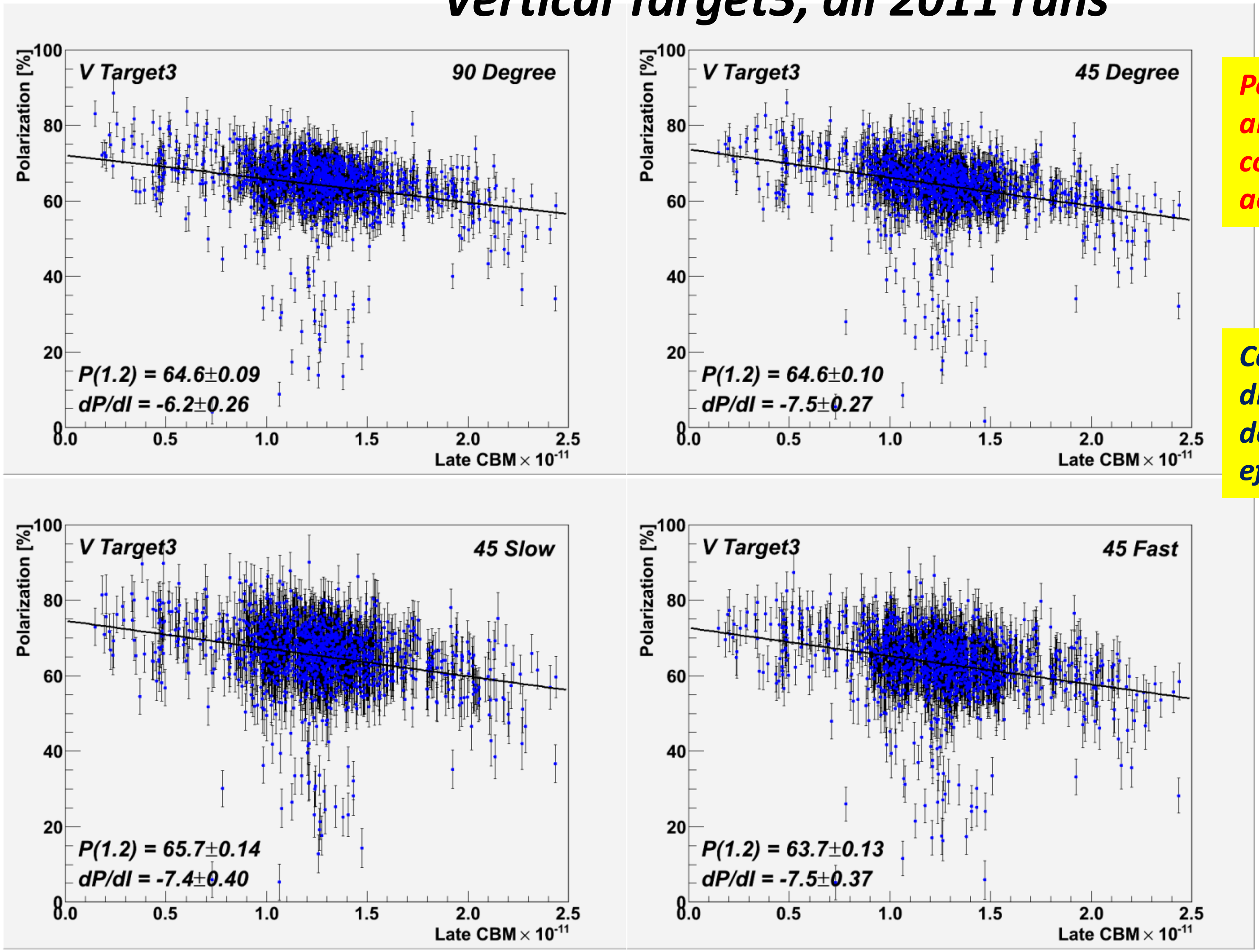
90 degree detectors (2,3,6,7)

45 degree detectors (1,4,5,8)



Polarization dependence on detector type

Polarization vs Beam Intensity (Late CBM), Vertical Target3, all 2011 runs



Polarization measured by all 3 types of detectors is consistent within 1-2% accuracy !

Can we explain slope difference for 90 and 45 degree detectors by rate effect ?

All 2011 data was included in the fit. Results of the fit should be used for comparison only

Polarization, P(1.2) , is given for intensity 1.2×10^{11}

Rate corrections

If detection efficiency is rate dependent $\qquad \varepsilon = \varepsilon_0(1 - kr)$

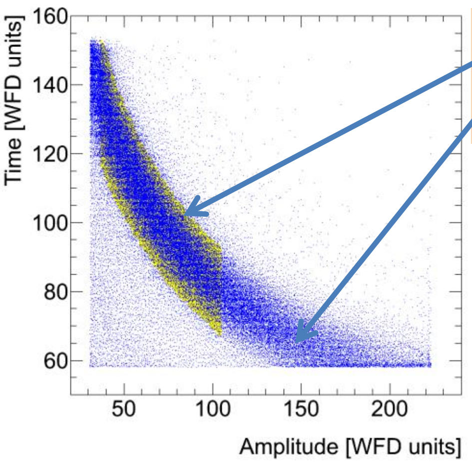
then measured polarization is also rate dependent $\qquad P_{\text{meas.}} = P_{\text{beam}} \dfrac{1-2kr}{1-kr} \approx P_{\text{beam}}(1-kr)$

Simple pileup (no background):

$$\varepsilon = \frac{1-e^{-r_0}}{r_0} \quad \Rightarrow \quad k \approx 0.5 \quad \Longrightarrow \quad 0.5 < k < 1$$

Signal overlapping

More realistic approximation: $\qquad k \approx 1 - \dfrac{r_0}{2r} \approx 0.75 \qquad (k<1)$



r_0 is number of good events per bunch per strip

r is total number of events per bunch per strip

Other contributions to the k :

- *Time cut (selection efficiency <u>may be</u> rate dependent)*
- *second order corrections to* $k: \quad k_{\text{eff}} = k(1+kr)$
- *second order corrections to rate:* $r \approx r_{\text{meas}}(1 + kr_{\text{meas}})$
- *…*

Separation of rate and emittance contributions to the dP/dI

$$\langle dP/dI \rangle = \langle dP/dI \rangle_{\mathrm{AGS}} + \langle dP/dR \rangle \langle dR/dI \rangle$$

Machine contribution ***Rate contribution***

- There are 48 pairs of Si strips in the AGS polarimeter.
- Each pair can measure polarization independently.
- In every run all pairs measure the same beam polarization
- The dependence of ***<dP/dI>*** on the *relative* rate in the pair allows us to calibrate rate corrections.

$$\langle dP/dI \rangle = \langle dP/dI \rangle_{\mathrm{AGS}} + \rho_i k_i n \langle P \rangle \langle dR/dI \rangle$$

i - is a strip pair number

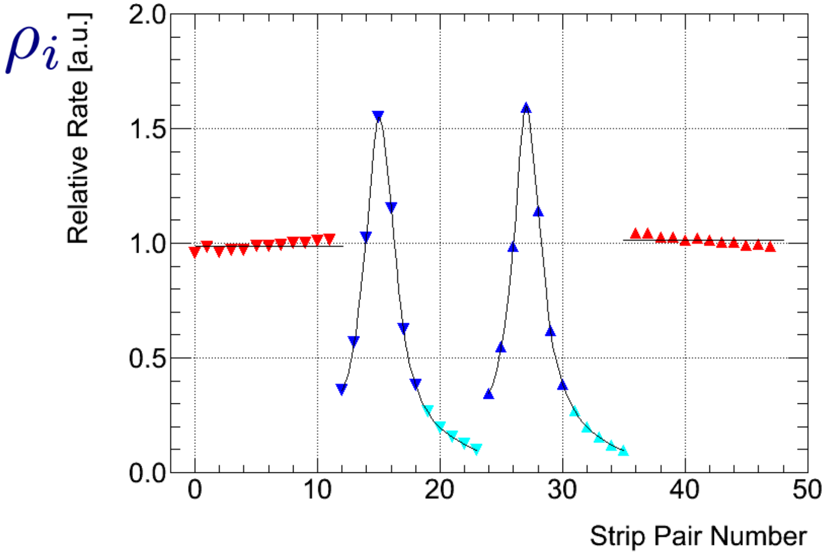
R - is average rate per strip (millions events per spill)

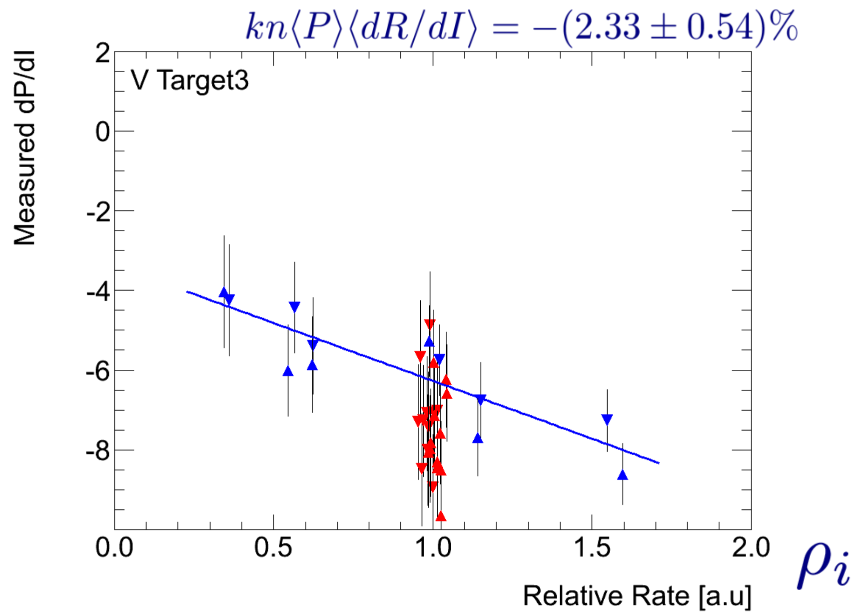
$\tilde{r}_i = nR_i$ - is rate in strip *i* (events per bunch), *n = 0.0528*

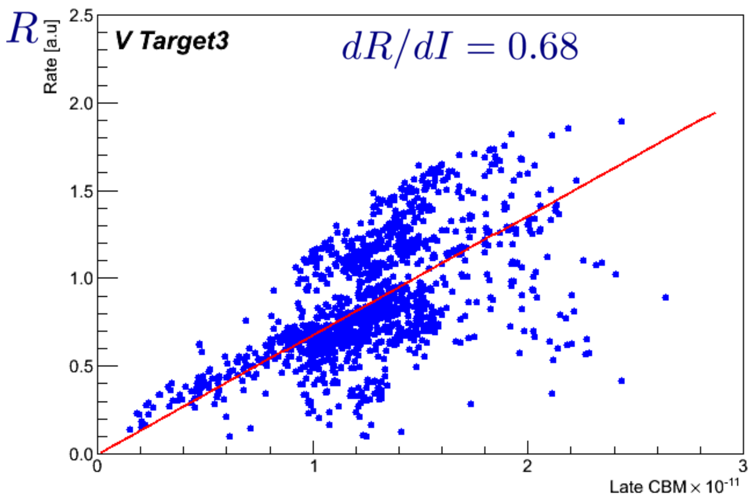
$\rho_i = R_i/R$ - is relative rate in the strip *I*

$k_i \to k$ assume factor *k is the same for all strips in the group of similar Si detectors*

Vertical Target3, all 2011 runs: *Strip Pairs*







The measured value of the rate effect factor

$$k_{\text{meas}} = 1.00 \pm 0.23$$

agrees well with a pileup based estimate

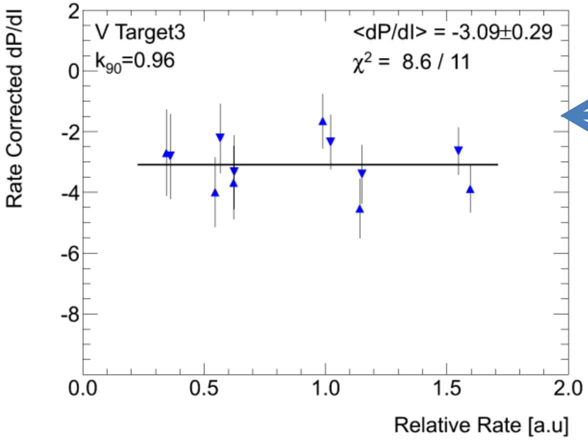
$$k_{\text{est}} \approx 0.75$$

Polarization dependence on beam intensity (averaged over ***all*** 2011 runs) :

$$\langle dP/dI\rangle_{\text{AGS}} = -(4.6 \pm 0.6)\%$$

Rate corrections to the acquired data

For every strip: $N_\pm \to N_\pm(1 + kr_\pm)$ ⇒ $N_\pm \to N_\pm \pm k\dfrac{N_+r_+ - N_-r_-}{2}$



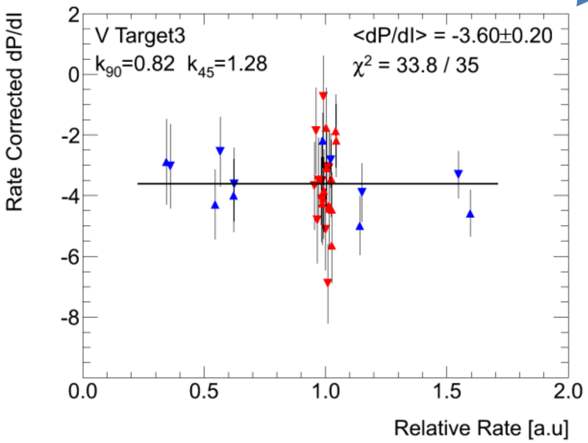
Fit data to determine k:

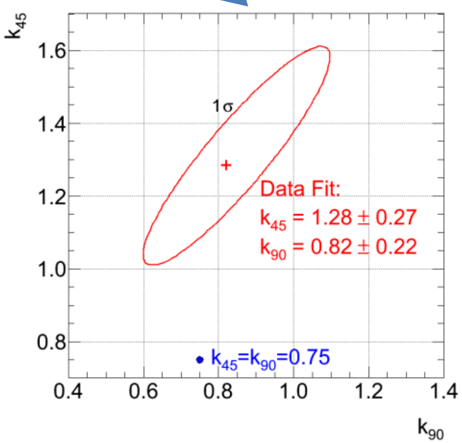
- 90 degree detectors only:

$$k_{90} = 0.96 \pm 0.26$$

- combined fit for 90- and 45 degree detectors

$$k_{90} = 0.82 \pm 0.22$$
$$k_{45} = 1.28 \pm 0.27$$



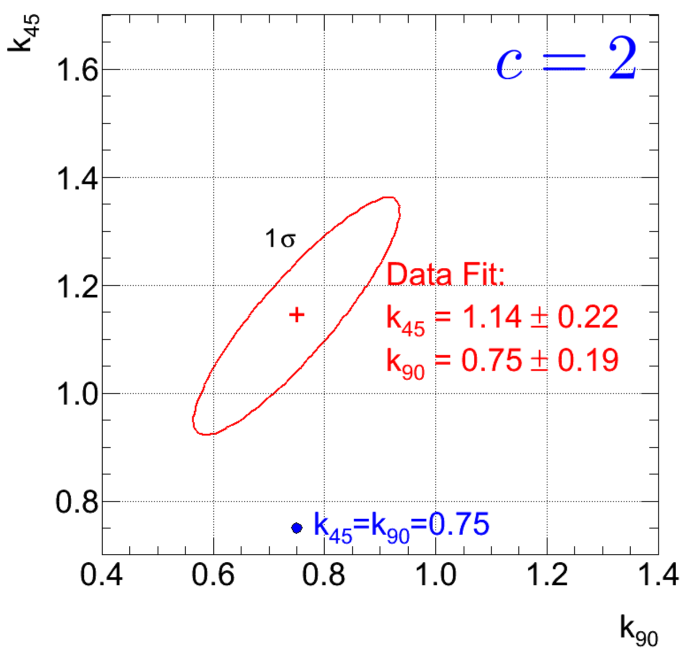


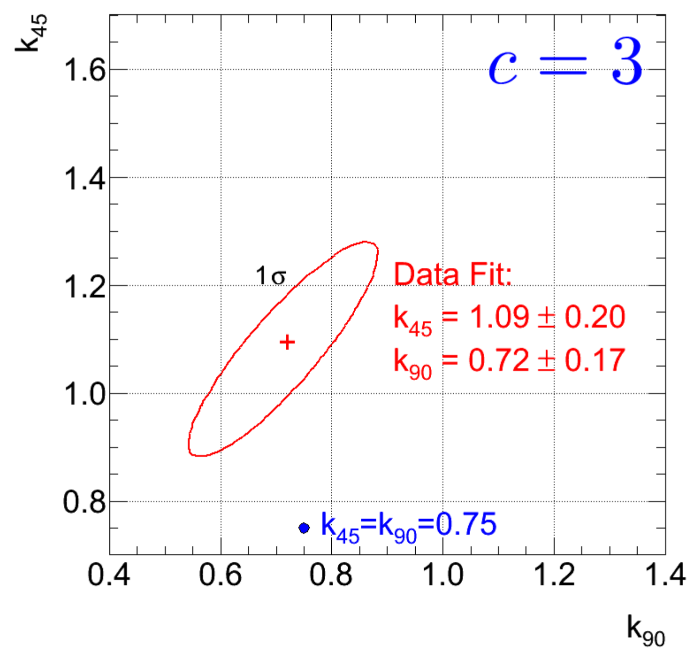
Non-linear corrections

$$\varepsilon = \varepsilon_0(1-kr) \Rightarrow P_{\text{meas.}} = P_{\text{beam}}\frac{1-2kr}{1-kr} \approx P_{\text{beam}}(1-kr-k^2r^2) \Rightarrow k_{\text{eff}} = k(1+kr)$$

$$r_{\text{meas}} = r\varepsilon(r) \Rightarrow r \approx r_{\text{meas}}(1+kr_{\text{meas}})$$

After summing all second order corrections: $k_{\text{eff}} = k(1+ckr)$ $\quad c = 3$, $\quad c \sim 2$ (nonlinearity in $\varepsilon(r)$)

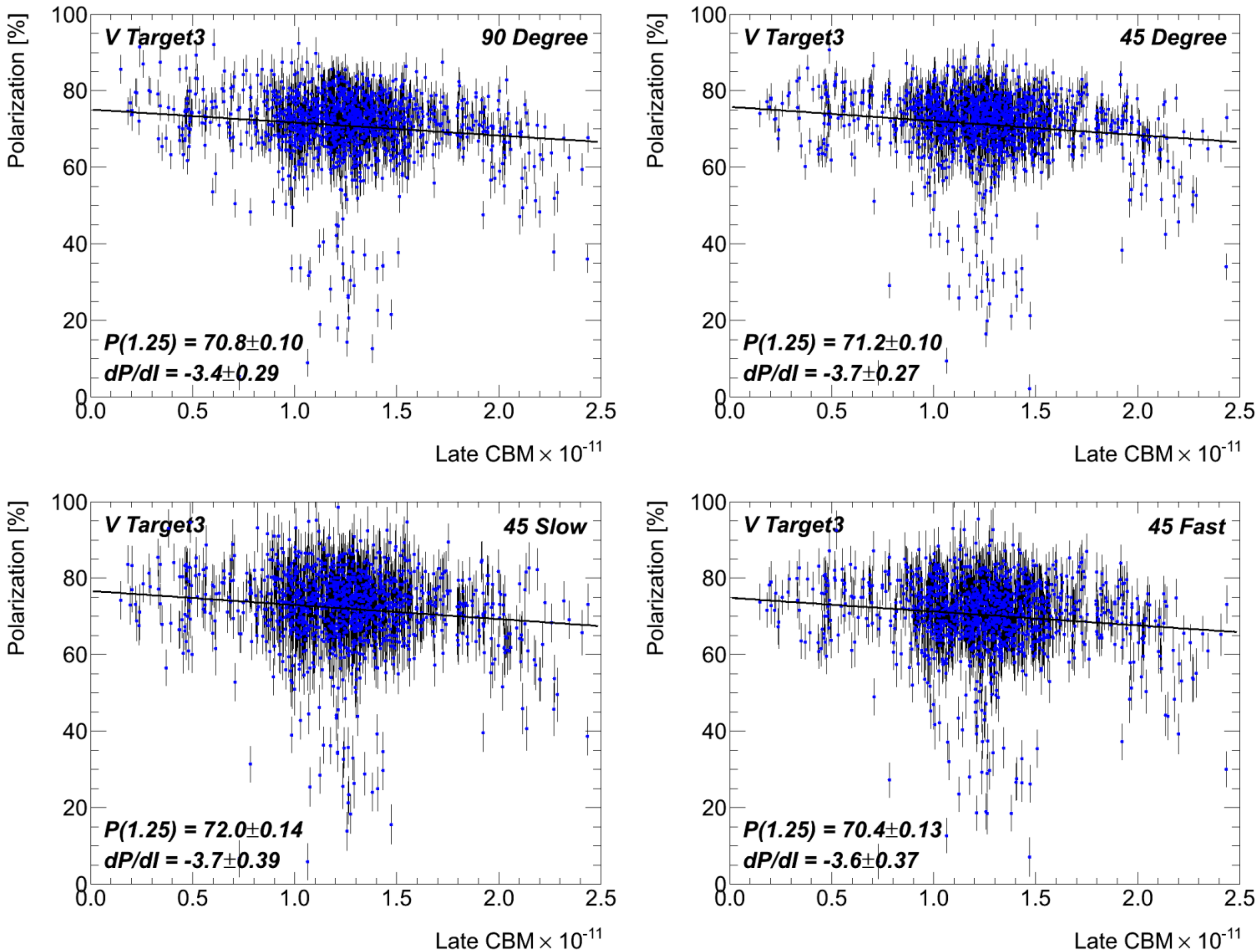




Nonlinearity corrections do change an esimate of k, but do not practically affect the measured polarization

Polarization vs Beam Intensity

(rate corrections k_{90}=0.82 k_{45}=1.28)



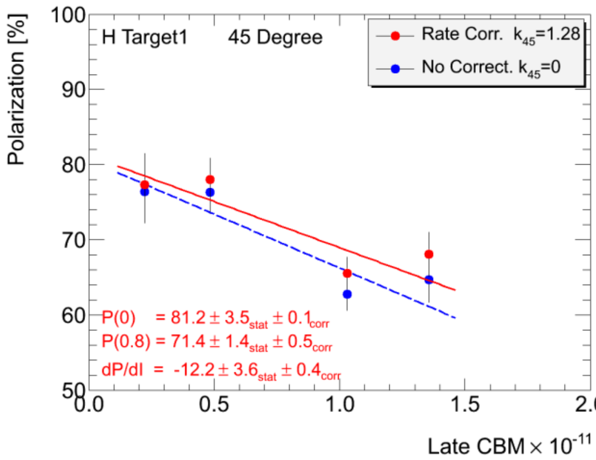
Mean Polarization <P(1.2)> was increased by 6.4% (10% relative)
Nonlinear corrections might be essential

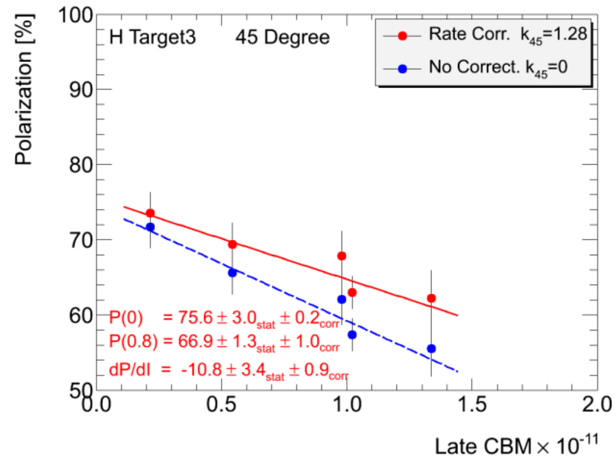
<dP/dI> was reduced by about 4 %

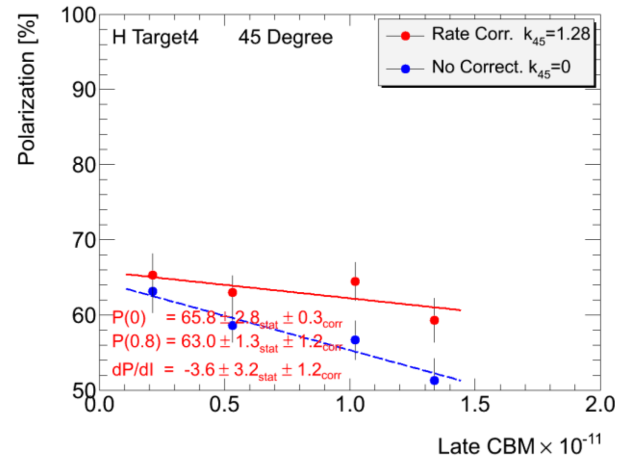
Rate corrections were applied for the following measurements

Runs	Targets	Comment
48958-48984	V3, V4, H1, H3, H4	Polarization vs. Intensity. Jump Quads OFF
50015-50044	V3	Polarization profile. Jump Quads ON (OC3)
50050-50065	V3	Polarization Profile. Jump Quads OFF (OC13)
50110-50130	V3, H1	Polarization vs. Intensity. Jump Quads ON.
50182-50203	V3, H1	Polarization measurement for fixed machine configuration. (during RHIC injection study)

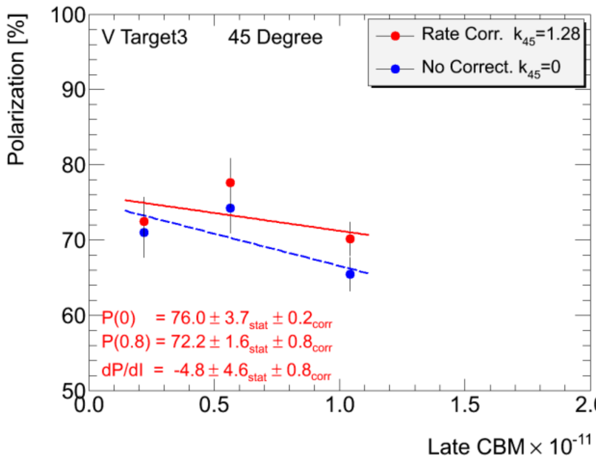
Runs 48958-49984 (Before Jump Quads were installed)

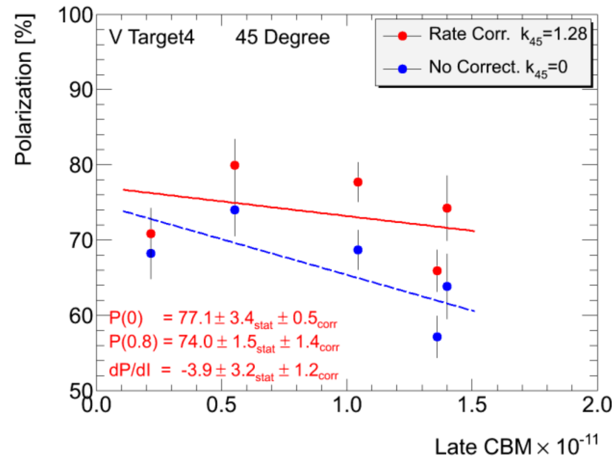






Blue: No Rate Corrections **Red: Rate Corr. *k_{45}=1.28***

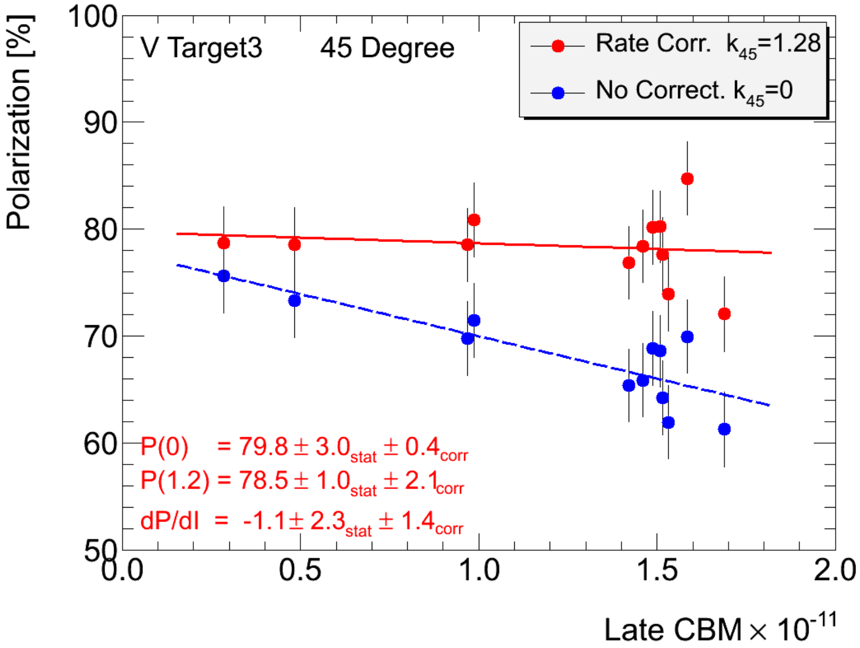


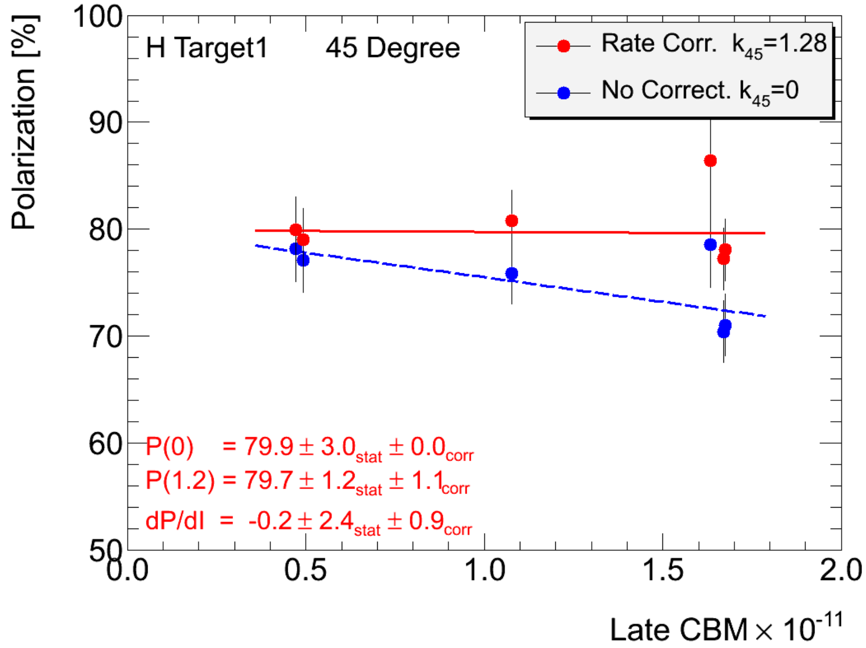


Runs 50110-50130. (Jump Quads ON)

Blue: No Rate Corrections

Red: Rate Corr. k_{45}=1.28

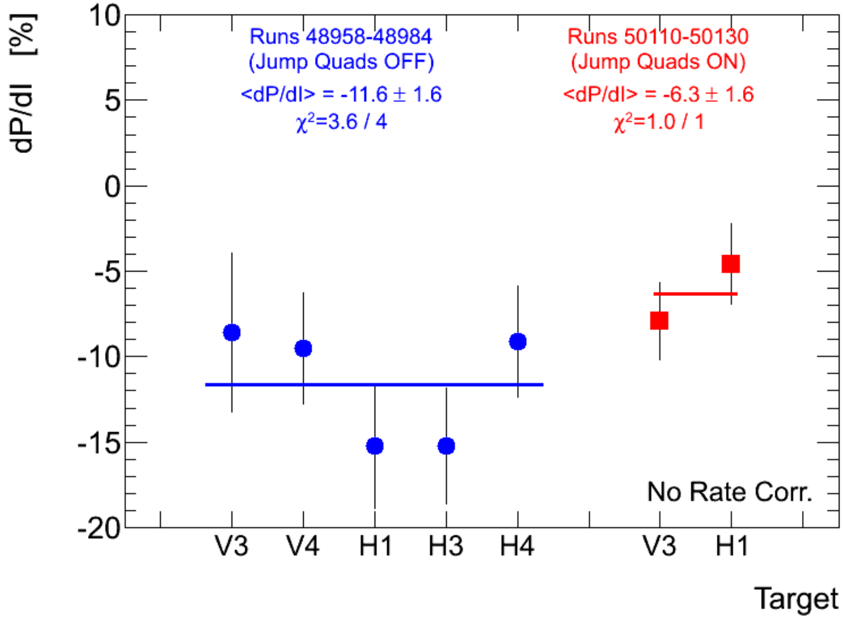




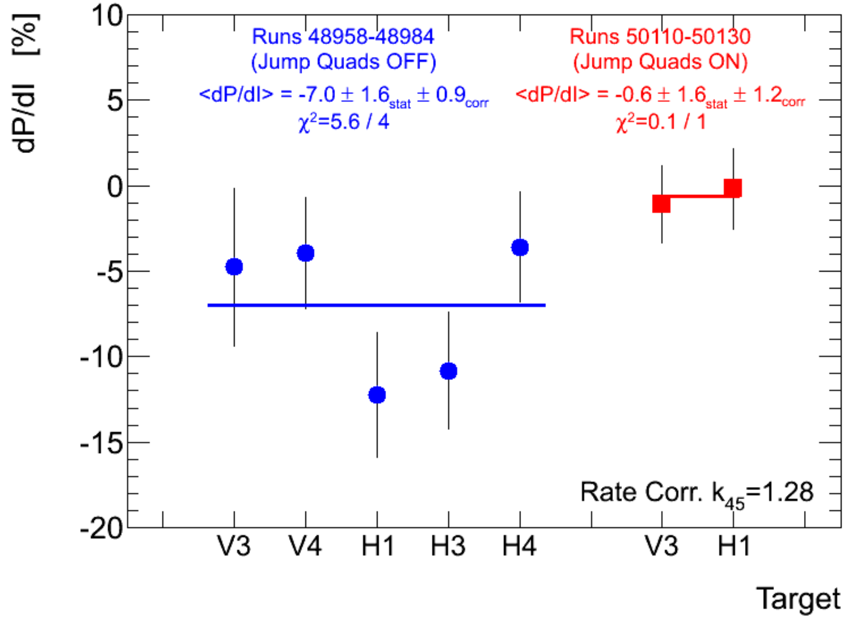
Rate correction increase measured Polarization by 20% (relative) for Vertical Target 3 at I=1.5

Summary for the dP/dI measurements

No Rate Corrections



Rate Correction: k_{45}=1.28



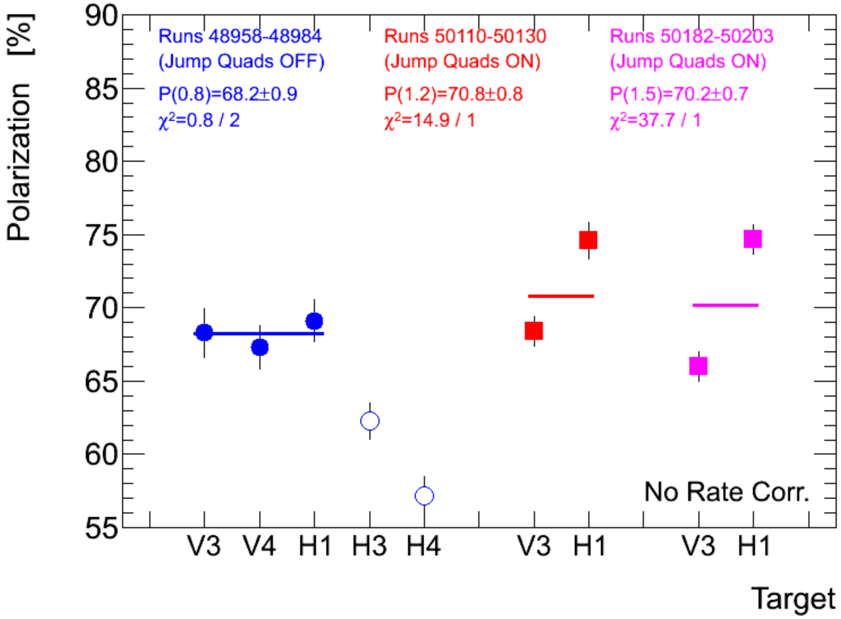
Blue: Jump Quads OFF — ***$dP/dI = -7.0 \pm 1.6_{stat} \pm 0.9_{corr}$***

Red: Jump Quads ON — ***$dP/dI = -0.6 \pm 1.6_{stat} \pm 1.2_{corr}$***

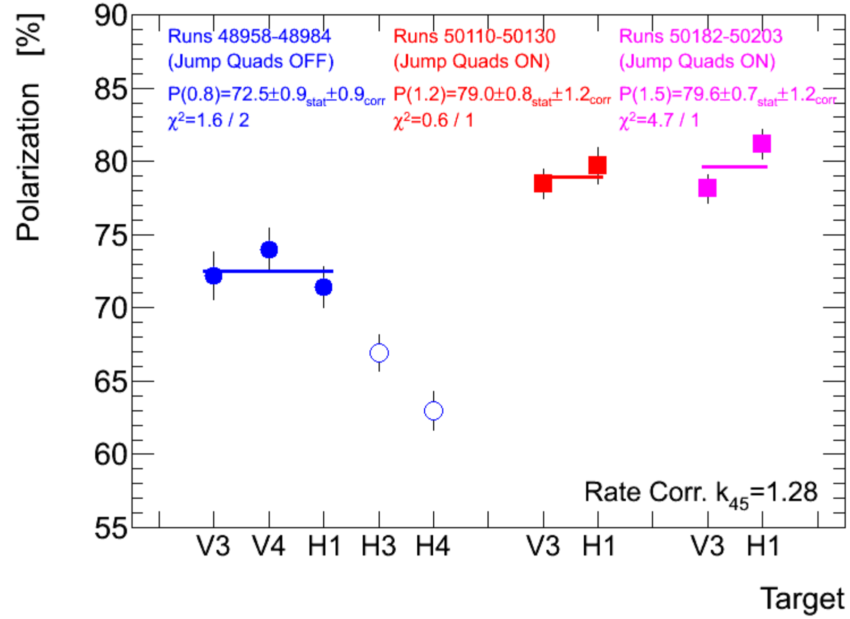
For Jump Quads,
no Polarization dependence on Intensity is observed

Summary for the mean polarization

No Rate Corrections



Rate Correction: k_{45}=1.28



Blue: Jump Quads OFF

$P(0.8) = 72.5 \pm 0.9_{stat} \pm 0.9_{corr}$

Red: Jump Quads ON

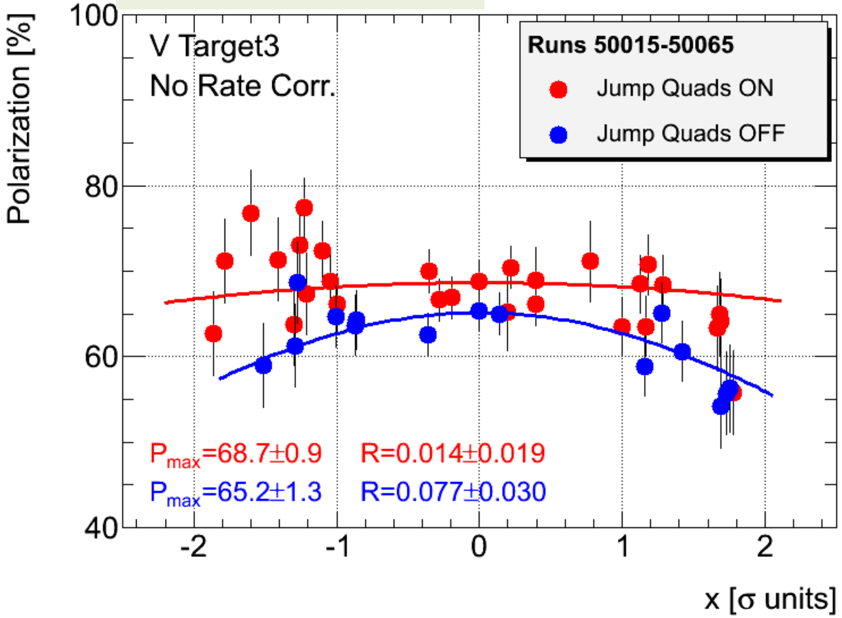
$P(1.2) = 79.0 \pm 0.8_{stat} \pm 1.2_{corr}$

$P(1.5) = 79.6 \pm 0.7_{stat} \pm 1.2_{corr}$

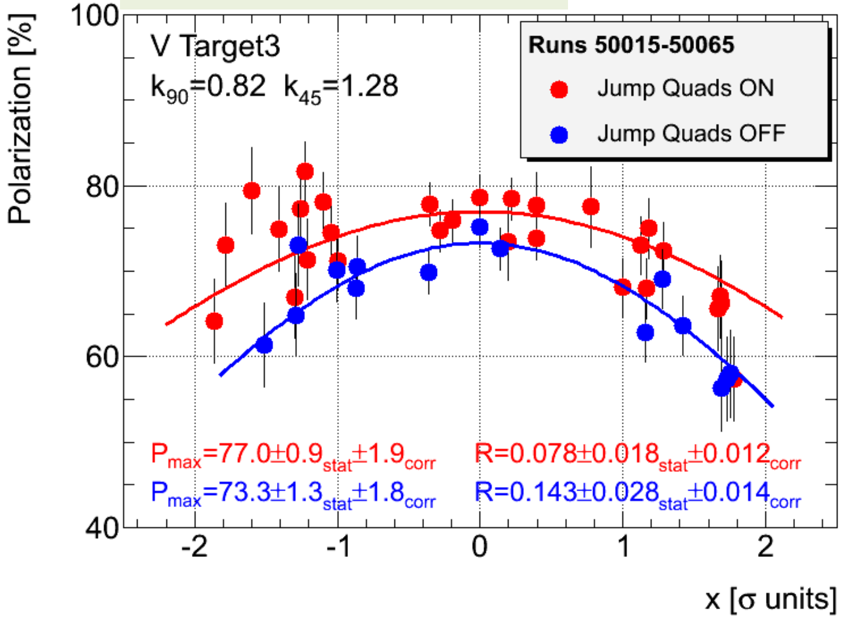
Polarization Profile

$$P(x) = P_{\max} e^{-Rx^2} \quad \Rightarrow \quad \langle P \rangle = P_{\max}/\sqrt{1+R}$$

No Rate Corrections



Rate Correction: k_{45}=1.28

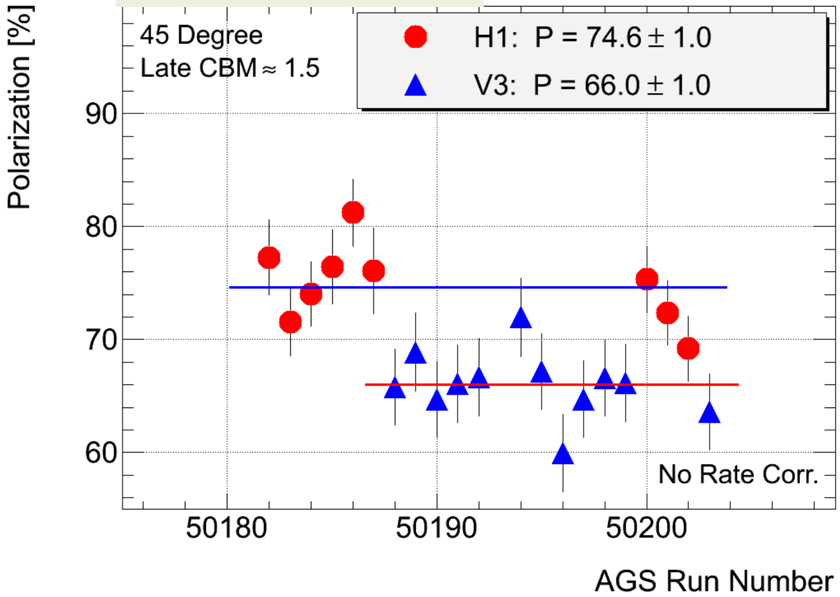


Blue: Jump Quads OFF **Red: Jump Quads ON**

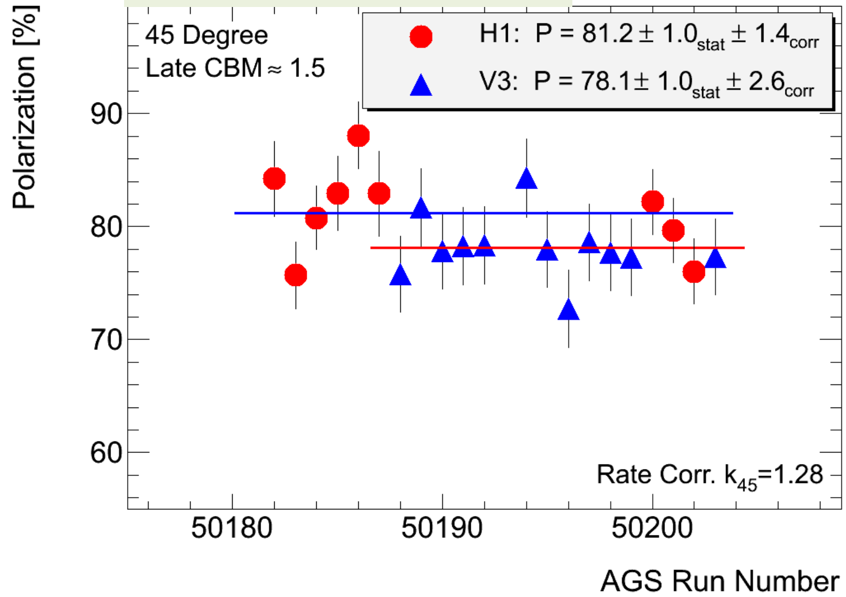
- ***The value of R (after rate correction) is consistent with RHIC measurements at injection***
- ***P_{max} is consistent with other polarization measurements***

Runs 50182-50203 (Jump Quads ON)

No Rate Corrections



Rate Correction: k_{45}=1.28



Discrepancy between measurements with H1 and V3:

$$P_{H1} - P_{V3} = 3.1 \pm 1.4_{stat} \pm 1.2_{corr}$$

V3 vs H1

Runs	J.Q.	<I>	V Target 3	H Target 1	$P_{H1} - P_{V3}$
48958-48984	OFF	0.8	$72.2 \pm 1.6_{stat} \pm 0.8_{corr}$	$71.4 \pm 1.4_{stat} \pm 0.5_{corr}$	$-0.8 \pm 2.2_{stat} \pm 0.3_{corr}$
50015-50044	ON	1.0	$77.0 \pm 0.9_{stat} \pm 1.9_{corr}$	-	-
50110-50130	ON	1.2	$78.5 \pm 1.0_{stat} \pm 2.1_{corr}$	$79.7 \pm 1.3_{stat} \pm 1.1_{corr}$	$1.2 \pm 1.6_{stat} \pm 1.0_{corr}$
50182-50203	ON	1.5	$78.1 \pm 1.0_{stat} \pm 2.6_{corr}$	$81.2 \pm 1.0_{stat} \pm 1.4_{corr}$	$3.1 \pm 1.4_{stat} \pm 1.2_{corr}$
				All Data:	$1.7 \pm 1.0_{stat} \pm 1.0_{corr}$
				Jump Quads ON only:	$2.3 \pm 1.1_{stat} \pm 1.1_{corr}$

Possible Explanations:

- ***Statistical fluctuation***
- ***Insufficient rate correction***
- ***Different horizontal and vertical polarization profiles***
- ***Energy losses in the target***

To evaluate average beam polarization we will suppose statistical fluctuation. The discrepancy will be included to the systematic error.

PRELIMINARY

Average Beam Polarization

$$\langle P \rangle = P_{\text{meas.}} / \sqrt{1+R}$$

"Standard" polarization normalization for the AGS:

Jump Quads	Late CBM	<P>	Extrapolation to I=2.0
OFF	0.8	$67.8 \pm 1.2_{stat} \pm 0.4_{corr} \pm 1.5_{syst}$	$59.4 \pm 2.2_{stat} \pm 1.5_{corr} \pm 1.5_{syst}$
ON	1.2	$76.1 \pm 0.9_{stat} \pm 0.7_{corr} \pm 1.5_{syst}$	$75.6 \pm 1.6_{stat} \pm 1.7_{corr} \pm 1.5_{syst}$

Remove Factor 1.11 from the A_N definition:

Jump Quads	Late CBM	<P>	Extrapolation to I=2.0
OFF	0.8	$61.0 \pm 1.1_{stat} \pm 0.4_{corr} \pm 1.5_{syst}$	$53.4 \pm 2.0_{stat} \pm 1.3_{corr} \pm 1.5_{syst}$
ON	1.2	$68.5 \pm 0.8_{stat} \pm 0.7_{corr} \pm 1.5_{syst}$	$68.0 \pm 1.4_{stat} \pm 1.5_{corr} \pm 1.5_{syst}$

- ***Systematic error (±1.5%) does not include $A_N(t)$ and/or energy calibration uncertainties.***
- ***Non-linear corrections should be applied.***

Summary

- *A method to control rate corrections was developed.*
- *Rate corrections were experimentally evaluated.*
- *Significant corrections to the measured polarization (up to 20%) were found.*
- *Rate correction were applied for some data samples.*
- *Effect of Jump Quads was studied.*
- *No visible polarization dependence on intensity (for Jump Quads)*
- *Average beam polarization with and without Jump Quads was estimated.*

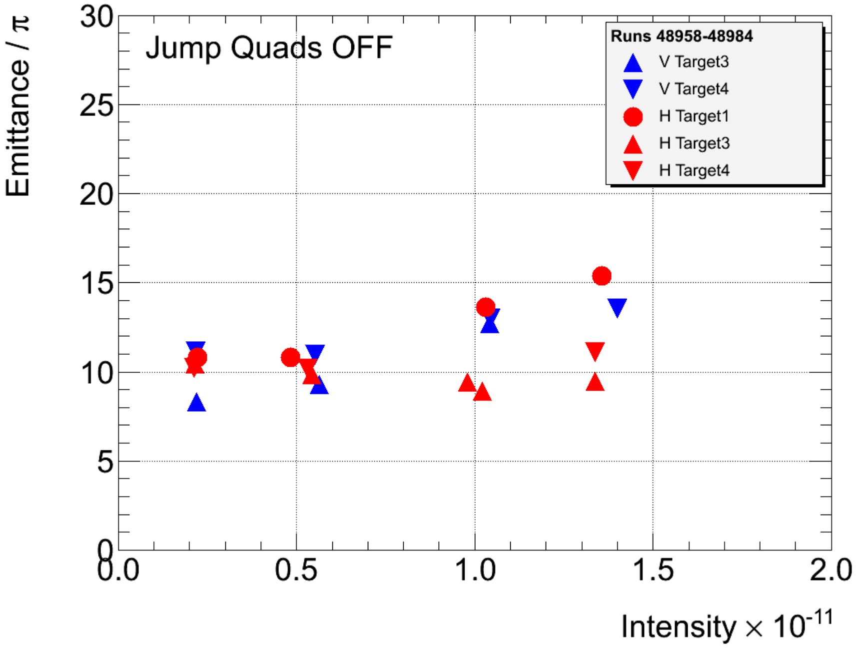
"Standard" Rate Corrections are suggested:

$$N_\pm \to N_\pm \pm (1 + r_+ + r_-)\frac{N_+ r_+ - N_- r_-}{2}$$

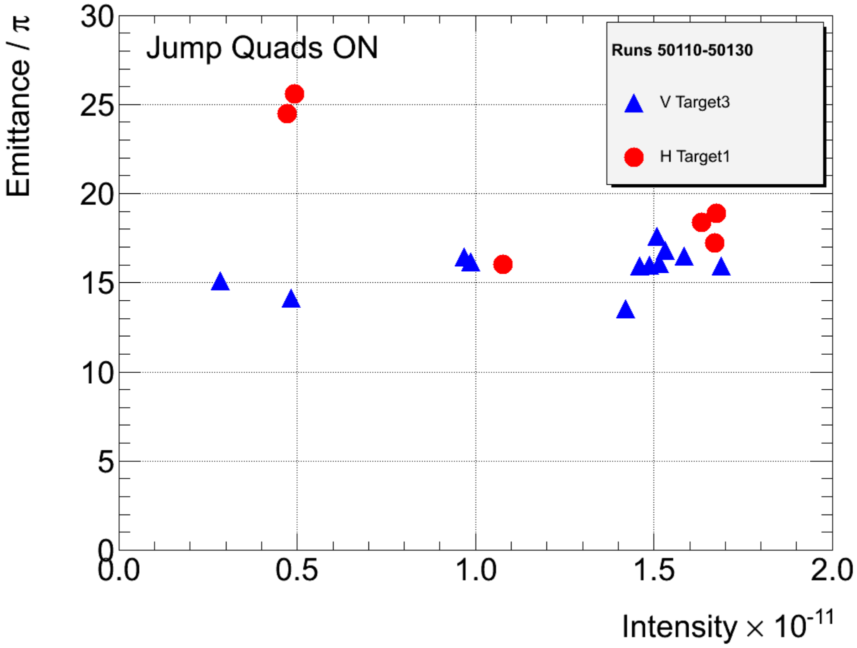
$$(k = 1 \quad c = 2)$$

Backup

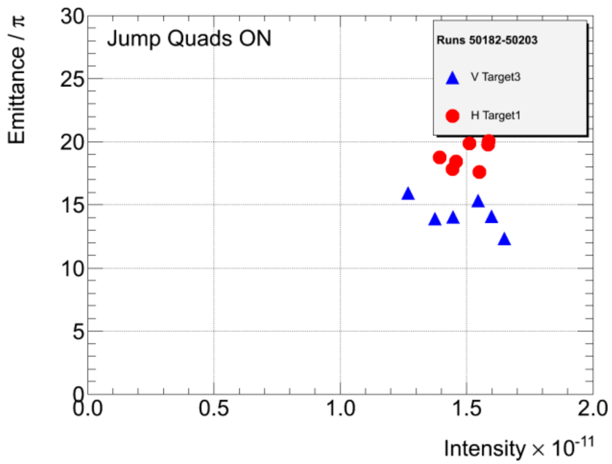
Emittance



Jump Quads OFF
Runs 48958-48984
V Target3
V Target4
H Target1
H Target3
H Target4
Emittance / π
Intensity × 10^{-11}
0.0
0.5
1.0
1.5
2.0
0
5
10
15
20
25
30



Jump Quads ON
Runs 50110-50130
V Target3
H Target1
Emittance / π
Intensity × 10^{-11}
0.0
0.5
1.0
1.5
2.0
0
5
10
15
20
25
30



Jump Quads ON
Runs 50182-50203
V Target3
H Target1
Emittance / π
Intensity × 10^{-11}
0.0
0.5
1.0
1.5
2.0
0
5
10
15
20
25
30